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Implementation Standard for White Space Operations

*Format for White Space Messaging
(WSM)*

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1.2 Amendments and Review

This document describes a commercial implementation strategy for white space administration and is not an official Standard. While Key Bridge is the author, this document includes and has been developed through a collaborative process and incorporates suggestions and editorial advice from many contributors.

The ultimate intent of the authors is to evolve this document, mature its implementation and provide it as a formal contribution such that it may become an Implementation Specification. Nevertheless, while the material in this document has been carefully reviewed, it remains subject to change without notice and should not be referred to as a formal Standard or Specification.

The authors welcome your feedback. Recipients of this document are invited to submit their comments, and if applicable, notification and supporting documentation, to Key Bridge Global by email to documents@keybridgeglobal.com or to the following mailing address:

Key Bridge Global LLC
1600 Tysons Blvd., Suite 1100
McLean, VA 22102, USA

1.3 No Warranty

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3 Introduction

This document specifies computer software object models and their corresponding XML encoding for **White Space Messaging (WSM)** between and amongst designated whitespace administrators and the various parties and agents that may wish to receive white space-related wireless service information.

The purposes of this document are to:

- Provide a standard machine-readable message format that enables Rules-compliant transactions of white space frequency availability information
- Provide a standardized messaging information format to more efficiently support cross-domain frequency coordination and administration as may be useful for white space-related and other wireless services
- Enable accurate and consistent Geo-location of unlicensed white space devices (WSD)
- Support machine-readable communication of white space device and spectrum occupancy descriptions to assist network planning and coexistence
- Support the implementation of white space administration in the TV broadcast bands through standardized implementations of secure information exchange of white space-related user, device and frequency information
- Enable the convenient storage, retrieval and archival of white space machine-to-machine transactions

The software object models defined by this document build upon the core **Wireless Service Information Format (WSIF)** specification as well as other common data primitives utilized and defined in related frameworks. The WSM is an XML-based information encoding and formatting scheme that builds and relies upon several other standard XML schema specifications. The following specifications are included by reference:

Schema	XSD Prefix	XSD Namespace URN
XSD	xs	http://www.w3.org/2001/XMLSchema
XMLDSIG	ds	http://www.w3.org/2000/09/xmlsig
WSIF	-	http://keybridgeglobal.com/2011/xml/wsif.xsd

4 Approach

In developing the **White Space Messaging Format (WSM)** specification the authors have attempted to incorporate and build upon other open and mature standards wherever possible. In cases where no satisfactory standard, data model or representation could be found the authors have followed best and standard practices whenever a new, original data model is required.

In some instances an existing standard representation required modification to establish FCC Rules-compliance, and in these cases the original specification was kept wholly intact with the required modification added in a manner matching the original standard's organizing strategy.

The WSM is intended to support white space operations within the TV Bands and beyond, and incorporates features and conventions necessary to accommodate the following necessary functions:

- Data Queries

White Space Rules describe the minimum set of information that must be exchanged when a requesting party wishes to query and receive white space information from an administrator depending upon the purpose. WSM accommodates multiple query types, from TV Band devices requesting frequency information for the purpose of initiating a wireless transmission to network planning inquiries seeking general occupancy data to consumers inquiring about spectrum availability.

5 Terms and Definitions

Computer software objects and their corresponding XML Types not defined in this document are defined in the Wireless Service Information Format (WSIF) specification.¹

Term	Definition
Administrator	A government-authorized whitespace administrator
WSIF	The Wireless Service Information Format specification

5.1 Units

The formats and units in the WSIF attribute definitions are the units of exchanged data. With regard to definitions and structure the WSIF specification makes the following fundamental assumptions for units of power, frequency and geodetic datum.

5.1.1 Power

WSIF power is exchanged in units of dBW in accordance with ITU treaty procedures, with power in dBW is calculated as:

$$P_{dBW} = 10 \log_{10} P_W$$

where

P_{dBW} = Power in dBW

P_W = Power in Watt

5.1.2 Frequency

WSIF frequency values are always noted in MHz. WSIF follows common practice and ITU convention in which a frequency value is formatted with between zero to five decimal places. Accordingly, all WSIF frequencies are measured and communicated in units of MHz, where the minimum allowable unit of frequency is 1.0 Hz. Frequency units are not otherwise explicitly declared.

5.1.3 Geodetic datum

All WSIF geo-location references are measured and communicated using the World Geodetic System of 1984 (WGS84) geodetic datum unless otherwise noted.²

¹ See Key Bridge Global LLC, *Wireless Service Information Format (WSIF)*

² See United States Department of Defense; *DoD WGS-1984 – Its Definition and Relationships with Local Geodetic Systems*; Washington, D.C.; 1985; Report AD-A188 815 DMA; 6127; 7-R-138-R; CV, KV;

6 Protocol Versions

The following protocol versions should be applied when using the specifications described in this document. The revision number may be optionally noted but is not required.

Object	Protocol Version	Revision Number
whiteSpaceQuery	2.0	0
whiteSpaceResponse	2.0	0

6.1 Protocol Security

This specification describes data formatting and encoding strategies to enable standardized messaging of WSIF information.

The Format for White Space Messaging (WSM) and the Wireless Service Information Format (WSIF) upon which it builds are composed of standard XML, and therefore are compatible with many commonly available message encryption and transport security technologies.

However, actual message encryption, counter-party authentication, communications transport and other security aspects of a working system are beyond this document's scope. Rules-compliant information assurance and WSM-based protocol security is the responsibility of each implementing party.

7 The WSM Object Model Overview

The WSM may be generally considered as a standardized query and response wrapper for a list of white space frequencies and other information required by Rule.³ An expanded WSM *whitespaceResponse* object is shown in Figure 1.

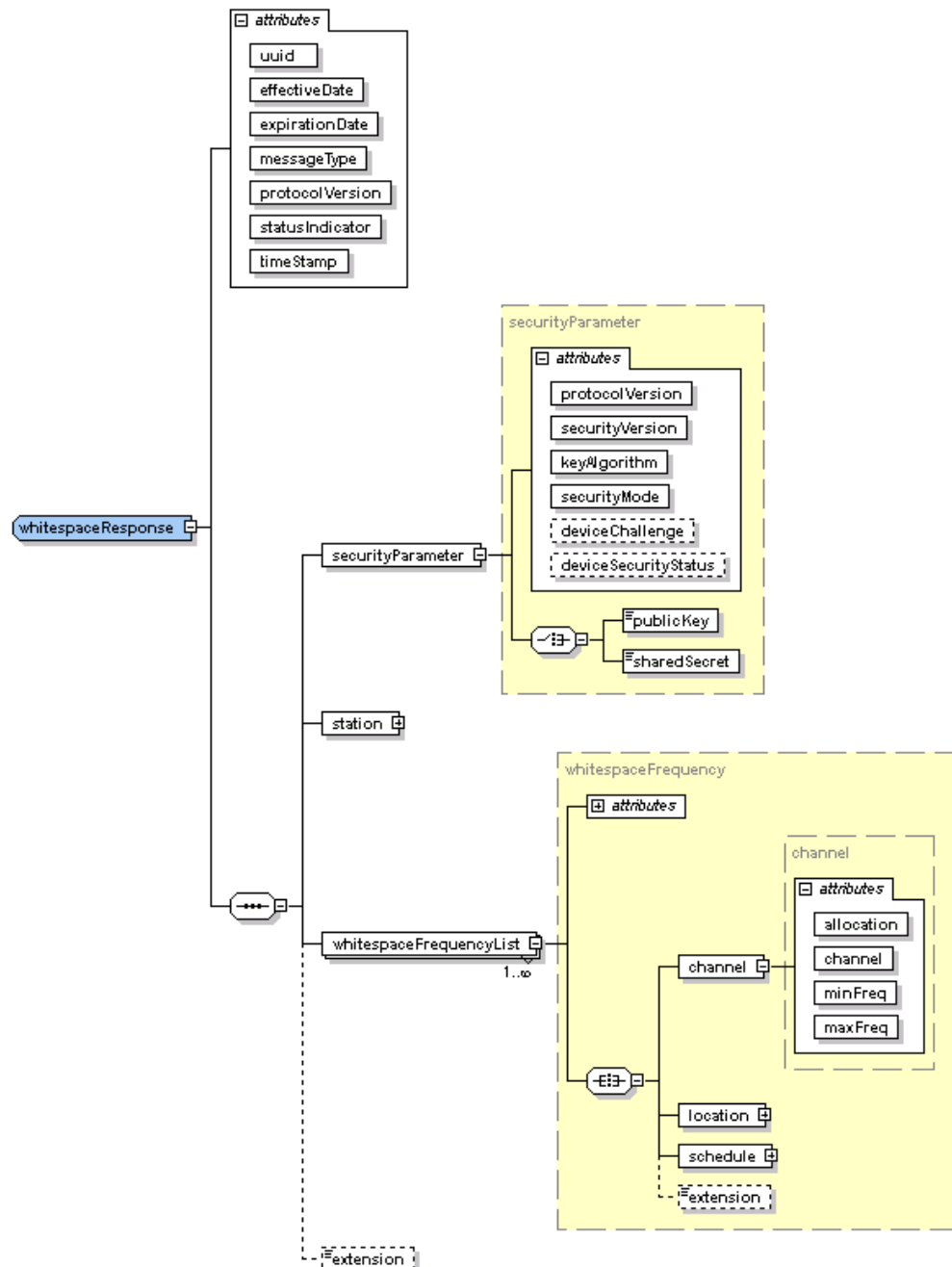
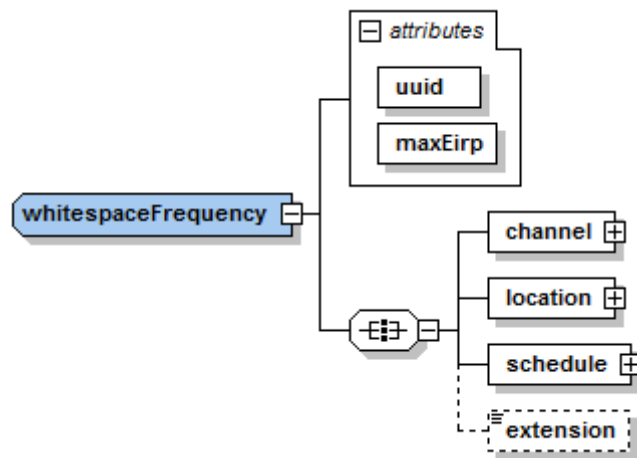


Figure 1: Expanded WSM *whitespaceResponse* message showing the *whitespaceFrequencyList* element contents and response attributes.

³ See 47 CFR Part 15, Subpart H: *Television Band Devices*. Specific data exchange and transaction handling requirements may be found throughout the Rule.

7.1 whitespaceFrequency



A WSM *whitespaceFrequency* object describes fully qualified, canonical frequency availability information as required for Rules-compliant TV Band white space operation.

Attributes and elements in the WSM *whitespaceFrequency* include the available frequencies plus location, schedule and transmit power constraints.

7.1.1 Definition

```

<xs:complexType name="whitespaceFrequency">
  <xs:all>
    <xs:element name="channel" type="channel"/>
    <xs:element name="location" type="location"/>
    <xs:element name="schedule" type="schedule"/>
    <xs:element name="extension" type="xs:string" minOccurs="0"/>
  </xs:all>
  <xs:attribute name="uuid" type="xs:string" use="required"/>
  <xs:attribute name="maxEirp" type="xs:float" use="required"/>
</xs:complexType>
  
```

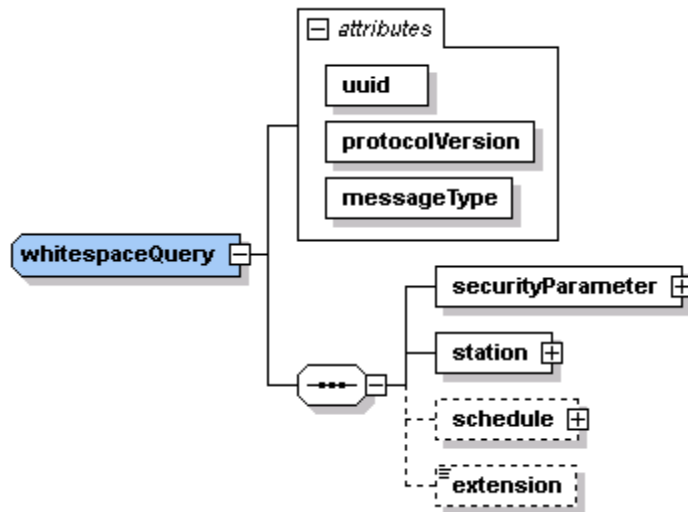
7.1.2 Elements

Element	Type	Documentation
channel	channel	<p>A WSIF <i>location</i> object.</p> <p>The frequency component of a white space message which fully describes the regulatory authority and definition of a frequency range and provides both the colloquial channel number plus the start and stop frequencies.</p>
location	location	<p>A WSIF <i>location</i> object.</p> <p>For TV Band devices operating in FIXED or TRANSPORTABLE mode (as specified in the <i>station.transmitter.tvbdMode</i> attribute) the <i>location.coordinate</i> element shall be set to the longitude/latitude values provided by the inquiring device.</p> <p>For TV Band devices operating in a MOBILE context (as specified in the <i>station.transmitter.tvbdMode</i> attribute) the location where this <i>whitespaceFrequency</i> was calculated shall be indicated by setting the longitude/latitude values in the <i>location.coordinate</i> and shall further indicate the geographic extent that this <i>whitespaceFrequency</i> is valid by providing a geographic contour in the <i>location.geometry.polygon</i> element.</p> <p>The <i>location.geometry.envelope</i> element may be optionally provided by administrators for device and end-user convenience but the <i>envelope</i> element shall not be used for purposes of determining frequency availability.</p>
schedule	schedule	<p>A WSIF <i>schedule</i> object.</p> <p>The time component of availability indicating when the information contained in this WSM <i>whitespaceFrequency</i> object becomes valid and when it expires.</p> <p><i>Key Bridge implementation</i></p> <p>Gaps in availability are communicated through the use of recurrence.</p>
<i>extension</i>	xs:string	<p>A URL-ENCODED string containing key/value pairs that may provide supplementary information or otherwise extend this object.</p>

7.1.3 Attributes

Attribute	Type	Documentation
uuid	xs:string	<p>A universally unique identifier (UUID) assigned by an Administrator that is associated with this WSM <i>whitespaceFrequency</i>.</p>
maxEIRP	xs:float	<p>The maximum allowable equivalent isotropically radiated power (EIRP) that a white space device may transmit on the indicated channel.</p> <p>Provided in dBW.</p>

7.2 whitespaceQuery



The WSM *whitespaceQuery* object is a generalized query message wrapper that any white space client (e.g. a white space device, software application, coexistence manager, etc.) may use to request information from a white space administrator as part of a Rules-compliant data transaction.

7.2.1 Definition

```

<xs:complexType name="whitespaceQuery">
  <xs:all>
    <xs:element name="securityParameter" type="securityParameter"/>
    <xs:element name="station" type="station"/>
    <xs:element name="schedule" type="schedule" minOccurs="0"/>
    <xs:element name="extension" type="xs:string" minOccurs="0"/>
  </xs:all>
  <xs:attribute name="uuid" type="xs:string" use="required"/>
  <xs:attribute name="protocolVersion" type="xs:float" use="required"/>
  <xs:attribute name="messageType" type="xs:string" use="required"/>
</xs:complexType>

```

7.2.2 Elements

Element	Type	Documentation
<i>schedule</i>	schedule	A WSIF <i>schedule</i> object Used by white space devices to request temporary spectrum access (i.e. less than 24 hours).
securityParameter	securityParameter	A WSIF <i>securityParameter</i> object The inquiring party's security information, including the device's digital certificates, keys, or shared secrets, and any additional configuration information necessary to assure the secure exchange of information.
station	station	A WSIF <i>station</i> object Information about the inquiring station including antenna, location, transmitter details, etc.
<i>extension</i>	xs:string	A URL-ENCODED string containing key/value pairs that requesting devices may implement and administrators may support at their discretion to provide supplementary information or to otherwise extend this object.

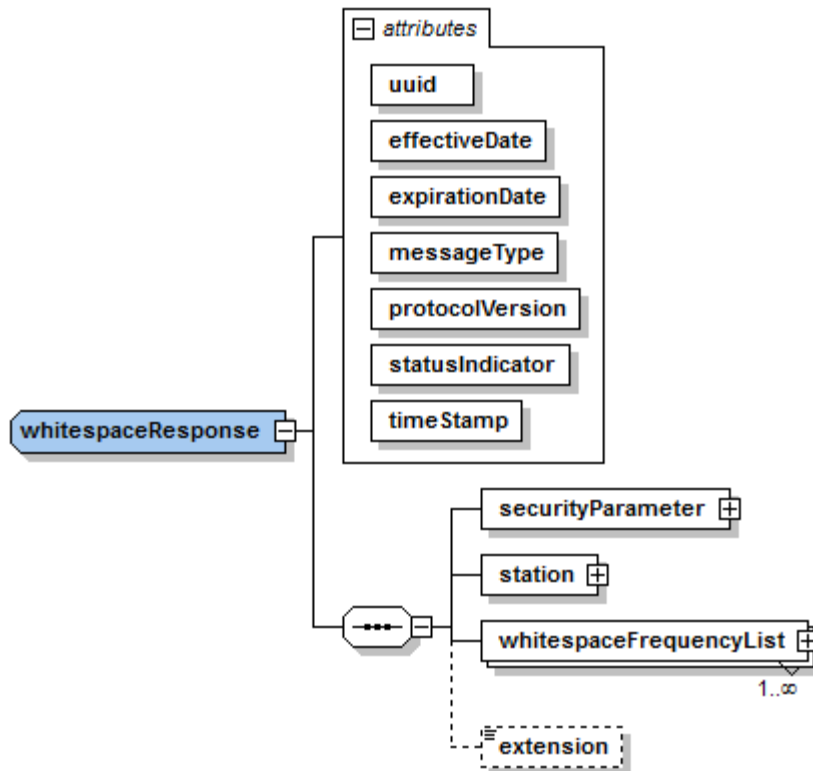
7.2.3 Attributes

Attribute	Type	Documentation
uuid	xs:string	A universally unique identifier (UUID) created by the inquiring agent (i.e. a TV band device, user software, etc.) and associated with this whitespace query message. <i>Key Bridge implementation</i> This <i>uuid</i> is used to correlate a <i>whitespaceResponse</i> message with this <i>whitespaceQuery</i> and to simplify logging and archival.
protocolVersion	xs:float	The message protocol version.
messageType	xs:string	The enumerated message type. <i>Key Bridge implementation</i> An <i>enumeratedCode</i> referencing a defined and described message type. See 8.3: <i>Message Types</i> for a description of allowed message types.

7.2.4 Validity

The *station.transmitterList* element shall consist of only *txTVBD* type WSIF *transmitter* objects. One or more valid and complete *station.contact* elements is required when the *txTVBD.tvbdMode* attribute indicates a Fixed-type white space device (e.g. *tvbdMode=FIXED*)

7.3 whitespaceResponse



A WSM *whitespaceResponse* object is a generalized message response structure that any white space administrator (e.g. a white space database implementation) may use to communicate white space information in a Rules-compliant data transaction. The WSM *whitespaceResponse* structure is intended to accommodate various responses to information queries from different white space clients such as, for example, white space devices (for transmission), management systems (not for transmission) and consumers (not for transmission).

7.3.1 Definition

```
<xs:complexType name="whitespaceResponse">
  <xs:sequence>
    <xs:element name="securityParameter" type="securityParameter"/>
    <xs:element name="station" type="station"/>
    <xs:element name="whitespaceFrequencyList" type="whitespaceFrequency"
nillable="true" minOccurs="1" maxOccurs="unbounded"/>
    <xs:element name="extension" type="xs:string" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="uuid" type="xs:string" use="required"/>
  <xs:attribute name="effectiveDate" type="xs:dateTime" use="required"/>
  <xs:attribute name="expirationDate" type="xs:dateTime" use="required"/>
  <xs:attribute name="messageType" type="xs:string" use="required"/>
  <xs:attribute name="protocolVersion" type="xs:float" use="required"/>
  <xs:attribute name="statusIndicator" type="xs:int" use="required"/>
  <xs:attribute name="timeStamp" type="xs:dateTime" use="required"/>
</xs:complexType>
```

7.3.2 Elements

Element	Type	Documentation
<code>securityParameter</code>	<code>securityParameter</code>	<p>A WSIF <i>securityParameter</i> object.</p> <p>Contains the administrator's security information including a public key digital certificate and any configuration information necessary to establish secure communications and/or to decrypt elements contained within this <i>whitespaceResponse</i> object.</p>
<code>station</code>	<code>station</code>	<p>A WSIF <i>station</i> object.</p> <p>Information about the inquiring station including location, transmitter, etc.</p> <p><i>Key Bridge implementation</i></p> <p>For TVBD responses a <i>station</i> element containing at minimum the station's <i>location</i> information shall be included in this white space response object.</p>
<code>whitespaceFrequencyList</code>	<code>whitespaceFrequency</code>	<p>A complete and canonical list of available and valid white space frequencies that is appropriate for the inquiring message's criterion.</p> <p>For white space devices, this WSM <i>whitespaceFrequencyList</i> element represents all channels available for unlicensed operation at the inquiring device's location or indicated geographic area and according to the schedule in this element.</p>
<i>extension</i>	<code>xs:string</code>	<p>A URL-ENCODED string containing key/value pairs that requesting devices may implement and administrators may support at their discretion to provide supplementary information or to otherwise extend this object.</p>

7.3.3 Attributes

Attribute	Type	Documentation
uuid	xs:string	<p>A universally unique identifier (UUID) created by the administrator and associated with this whitespace response message.</p> <p><i>Key Bridge implementation</i></p> <p>This <i>uuid</i> attribute is set to match the client's <i>whitespaceQuery.uuid</i> attribute and to simplify logging and archival.</p>
effectiveDate	xs:dateTime	<p>The date and time when this white space information should be considered effective.</p> <p><i>Key Bridge implementation</i></p> <p>The <i>effectiveDate</i> may be set in the future to accommodate frequencies that may become available at a later date or time.</p>
expirationDate	xs:dateTime	<p>The date and time when this white space information expires.</p> <p><i>Key Bridge implementation</i></p> <p><i>Key Bridge implementation</i></p> <p>The expiration date of this WSIF <i>schedule</i> as calculate from the start and end dates and this object's <i>schedule</i>'s recurrence configuration. For example: a one-day event (e.g. <i>dtstart</i> equal to <i>dtend</i>) with a recurrence for ten (10) days will have an <i>expiration</i> attribute set to ten (10) calendar days after DTSTART.</p>
messageType	xs:string	<p>The enumerated message type.</p> <p><i>Key Bridge implementation</i></p> <p>An <i>enumeratedCode</i> referencing a defined and described message type. See 8.3: <i>Message Types</i> for a description of allowed message types.</p>
protocolVersion	xs:float	The message protocol version.
timeStamp	xs:dateTime	When this <i>whitespaceResponse</i> message was created.
statusIndicator	xs:int	<p>The number of available white space channels included in this message.</p> <p><i>Key Bridge implementation</i></p> <p>A negative <i>statusIndicator</i> values indicates that an error condition has occurred, the details of which are provided in the <i>extension</i> element of this <i>whitespaceResponse</i> object.</p>

7.3.4 Validity

The *station.transmitterList* element shall consist of only *txTVBD* implementations of the *transmitter* interface template.

The client's indicate operating mode (as specified in the *station.transmitterList[0].tvbdMode* attribute) is echoed back to the client in the same location to confirm such operation is allowed.

Where the client's indicated (equals requested) TVBD mode of operation is prohibited the administrator must set the operating mode to an authorized TVBD mode and the client must operate according to the administrator-specified TVBD mode at the indicated location.

The *expirationDate* must be set in the future and after than the *effectiveDate*.

8 Appendix: Enumerated Codes

Note: The following enumerated codes are possibly specific to the Key Bridge implementation.

8.1 Equipment Authorization Agencies

Used for the *ea* attribute of the *transmitter* object.

Enumerated Code	Country	Description
us.fcc	USA	Federal Communications Commission

8.2 Operating Mode

Used for the *operatingMode* attribute of the *operatingParameter* object.

Enumerated Code Name	Description	Mode
us.ws.operatingMode.TVBD.CLIENT	A TVBD operating in client mode	Mode I
us.ws.operatingMode. TVBD.FIXED	A permanently installed (non-transportable, non-mobile) TVBD	Fixed
us.ws.operatingMode. TVBD.MOBILE	A mobile Personal Portable TVBD	Mode II
us.ws.operatingMode. TVBD.TRANSPORTABLE	A transportable (not mobile) Personal Portable	Mode II

8.3 Message Types

Message types may be extended as needs require.

Enumerated Code Name	Description
us.ws.messageType.TVBD.QUERY	The message is a certified client-initiated query for white space frequency information for the purposes of transmission. Examples of certified clients include FCC-certified white space devices and other devices authorized to operate within the band (e.g. wireless microphones, medical telemetry, PLMRS systems, etc.)
us.ws. messageType. TVBD.RESPONSE	The message is a response to a TVBD.QUERY request for information.
us.ws. messageType. INFORMATION.QUERY	The message is a non-certified client-initiated query for general (possibly white-space) frequency information NOT for the purposes of transmission. Examples of non-certified clients include network management and planning systems, client software applications, etc.
us.ws. messageType. INFORMATION.RESPONSE	The message is a response to an INFORMATION.QUERY request for information.

9 Appendix: XML Registry

The WSM is an XML-based information encoding and formatting scheme that builds and relies upon several other standard XML schema specifications. The following specifications are included by reference:

Schema	XSD Prefix	XSD Namespace URN
XSD	xs	http://www.w3.org/2001/XMLSchema
XMLDSIG	ds	http://www.w3.org/2000/09/xmlsig

9.1 Key Bridge XML Repository

The structure of WSM elements and documents is defined using XML Schemas language. The Schema and this document are published on the Key Bridge web site at <https://keybridgeglobal/2011/xml/>. The main file is **wsm.xsd**.

XML schema available online at http://keybridgeglobal/2011/xml/wsm.xsd
--

9.2 WSIF Schema Snapshot

The following schema is provided for reference only.

THE ONLINE SCHEMA IS AUTHORITATIVE.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" version="1.0">
  <xs:complexType name="whitespaceFrequency">
    <xs:sequence>
      <xs:element name="channel" type="channel"/>
      <xs:element name="location" type="location"/>
      <xs:element name="schedule" type="schedule"/>
      <xs:element name="extension" type="xs:string" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="uuid" type="xs:string" use="required"/>
    <xs:attribute name="maxEirp" type="xs:float" use="required"/>
  </xs:complexType>
  <xs:complexType name="whitespaceQuery">
    <xs:sequence>
      <xs:element name="securityParameter" type="securityParameter"/>
      <xs:element name="station" type="station"/>
      <xs:element name="schedule" type="schedule" minOccurs="0"/>
      <xs:element name="extension" type="xs:string" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="uuid" type="xs:string" use="required"/>
    <xs:attribute name="protocolVersion" type="xs:float" use="required"/>
    <xs:attribute name="messageType" type="xs:string" use="required"/>
  </xs:complexType>
  <xs:complexType name="whitespaceResponse">
    <xs:sequence>
      <xs:element name="securityParameter" type="securityParameter"/>
      <xs:element name="station" type="station"/>
      <xs:element name="whitespaceFrequencyList" type="whitespaceFrequency"
maxOccurs="unbounded"/>
      <xs:element name="extension" type="xs:string" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="uuid" type="xs:string" use="required"/>
    <xs:attribute name="effectiveDate" type="xs:dateTime" use="required"/>
    <xs:attribute name="expirationDate" type="xs:dateTime" use="required"/>
    <xs:attribute name="messageType" type="xs:string" use="required"/>
    <xs:attribute name="protocolVersion" type="xs:float" use="required"/>
    <xs:attribute name="statusIndicator" type="xs:int" use="required"/>
    <xs:attribute name="timeStamp" type="xs:dateTime" use="required"/>
  </xs:complexType>
</xs:schema>
```

END